<Solid State Chemistry> Artificial Lattice Alloys

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- Artificial Lattice Alloys -

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Visitor
Dr BACZEWSKI, Lech Tomasz — Institute of Physics, Polish Academy of Sciences, Poland, 9 February–8 May 2002

Scope of Research

Metallic thin films, multilayers, and nanostructures are prepared by ultrahigh-vacuum deposition and electron-beam lithography. Magnetic and electric transport properties are studied using various experimental techniques including Mössbauer spectroscopy, x-ray magnetic scattering, and neutron diffraction. Novel magnetic and transport properties are explored by engineering the size and shape of magnetic materials.

Research Activities (Year 2002)

Presentations

Magnetization Switching of the Vortex Core at the Center of Circular Permalloy Dot, Okuno T, Shigeto K, Mibu K, Shinjo T, Yokoyama Y (AIST), Suzuki Y (AIST), Ono T (Osaka Univ.), 17th International Colloquium on Magnetic Films and Surfaces, 5 March.

Magnetic Domain Wall in a Nano-Contact between Two NiFe Wires, Miyake K, Shigeto K, Mibu K, Shinjo T, Suzuki Y (AIST), Yokoyama Y (AIST), Ono T (Osaka Univ.), 17th International Colloquium on Magnetic Films and Surfaces, 7 March.

Growth-Orientation Dependence of Cr Magnetic Moments in Fe/Cr Multilayers Studied using ^{119}Sn Mössbauer Spectroscopy, Jiko N, Almokhtar M, Mibu K, Shinjo T, 57th Annual Meeting of the Physical Society of Japan, 25 March.

The Variation of the Magnetic Structure of the Domain Wall Formed in the Nano-Contact between Two NiFe Wires, Miyake K, Shigeto K, Mibu K, Shinjo T, Yokoyama Y (AIST), Suzuki Y (AIST), Ono T (Osaka Univ.), 57th Annual Meeting of the Physical Society of Japan, 25 March.

Size Dependence of Switching Field of Turned-Up Magnetization at the Center of a Magnetic Dot, Okuno T, Shigeto K, Ono T (Osaka Univ.), Yokoyama Y (AIST), Suzuki Y (AIST), Mibu K, Shinjo T, 57th Annual Meeting of the Physical Society of Japan, 25 March.

Switching of Turned-Up Magnetizations in a Cross-Tie Wall in a Magnetic Dot, Okuno T, Shigeto K, Ono T (Osaka Univ.), Mibu K, Shinjo T, 2002 Autumn Meeting of the Physical Society of Japan, 6 September.

Magnetism of Cr in Cr(110)/Sn Multilayers, Jiko N, Mibu K, Takeda M (Tohoku Univ.), Suzuki J (JAERI), Shinjo T, 2002 Autumn Meeting of the Physical Society of Japan, 8 September.

Curie Temperature and Magnetic Properties of Gd Layers in Gd/Cu Multilayers, Ohkochi T, Hosoito N, Mibu K, 2002 Autumn Meeting of the Physical Society of Japan, 8 September.

The Observation of a Magnetic Domain Wall Injected into a Ferromagnetic Wire, Miyake K, Mibu K, Shinjo T, 2002 Autumn Meeting of the Physical Society of Japan, 8 September.

Magnetic Structure of a Diamond Shape Dot Array Connected with Nano-Contacts, Miyake K, Mibu K, Shinjo T, 26th Annual Conference on Magnetics in Japan, 17 September.

Award

Poster Award, Magnetic Domain Wall in a Nano-Contact between Two NiFe Wires, Miyake K, *et al.*, 17th International Colloquium on Magnetic Films and Surfaces, 7 March.

Topics

The former professor Teruya Shinjo retired on 31 March 2002.

Magnetic Structures of Diamond-Shaped NiFe Dot Arrays

Arrays of diamond-shaped NiFe dots were fabricated by an electron-beam lithography and lift-off method, and the magnetization arrangements were investigated using magnetic force microscopy. Typical size parameters and a scanning electron microscopy image are shown in Fig 1. The thickness of the sample was set to be 10 nm. A series of patterns with different designed distance between dots were drawn by electron beams on the same substrate. It was found that disconnected dot arrays and connected dot arrays with different contact sizes were incidentally fabricated after the lift-off process.

Figure 2 shows a magnetic force microscopy image at zero field after a magnetic field of 5 kOe was applied parallel to the short axis of the dots. The magnetic charge distribution appears as black and white contrasts. It is clearly shown that each dot has a single magnetic domain state and the magnetization aligns along the long axis of the dots. The magnetizations in neighboring dots are oriented antiparallel with a few exceptions due to magnetostatic interaction between the dots. Eventually, a very small domain wall is effectively confined in each nanocontact area. Such samples are promising model systems to investigate magnetoresistance caused by magnetic domain walls.

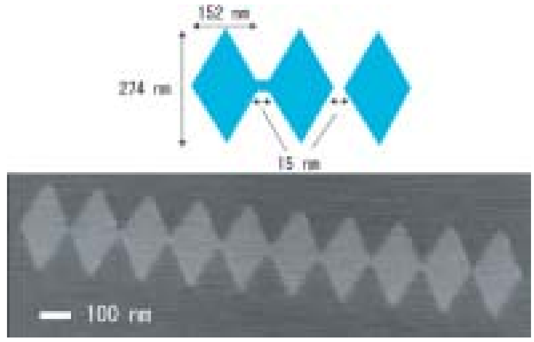

Fig. 1 Illustration of the sample structure and scanning electron microscopy image of diamond-shaped NiFe dot arrays.

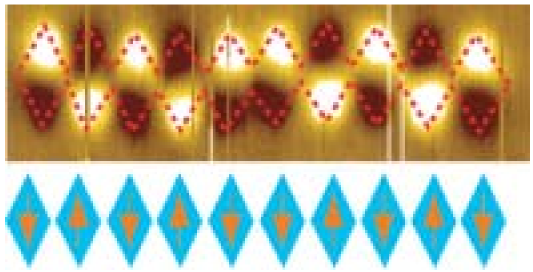

Fig. 2 Magnetic force microscopy image and schematic illustration of the magnetic structure. The rad dashed lines indicate the shape of the dots.

Magnetization Reversal of Turned-Up Magnetization in Track-Shaped NiFe Dots

When a circular dot is fabricated from a soft magnetic material such as NiFe, a magnetic vortex structure is stabilized due to a competition between exchange interaction and magnetostatic interaction. A nanoscale singularity spot with perpendicular magnetization, which is called "turned-up magnetization", is formed at the center of the vortex. Such a singularity spot appears not only at the center of a "circular-vortex", but also at the center of an "anti-vortex". In order to investigate magnetization reversal of turned-up magnetizations at both types of vortex cores, track shaped (quasi-ellipsoidal) submicron dots with 50 nm in thickness were made of NiFe alloy using electron-beam lithography (Fig. 3). The switching field of turned-up magnetization for magnetic field normal to the sample plane was measured using magnetic force microscopy. It was found that the switching field at the anti-vortex core is smaller than that at a circular-vortex core by about 1000 Oe. It was also demonstrated that the direction of the magnetizations at three singularity spot can be controlled by applying magnetic field perpendicular and parallel to the sample plane.

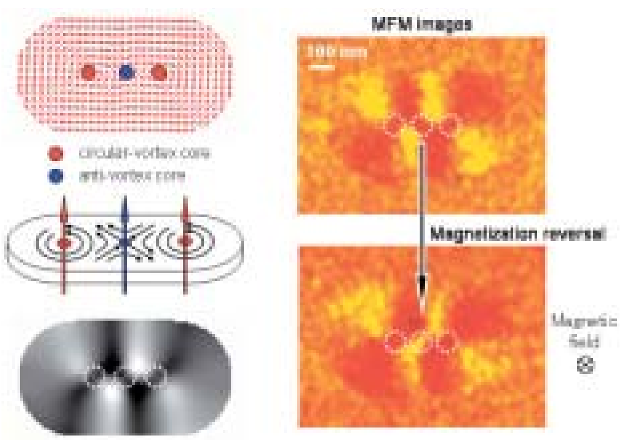

Fig . 3 Circular-vortex cores and an anti-vortex core formed in a track-shaped NiFe dot, and magnetization reversal of turned-up magnetization at the anti-vortex core.